Complete Summary

GUIDELINE TITLE

Seizures—child.

BIBLIOGRAPHIC SOURCE(S)

Strain JD, Gunderman R, Blatt ER, Coley BD, Fordham L, Podberesky DJ, Prince JS, Expert Panel on Pediatric Imaging. Seizures - child. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 8 p. [26 references]

GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: Strain JD, Kushner DC, Babcock DS, Cohen HL, Gelfand MJ, Hernandez RJ, McAlister WH, Parker BR, Royal SA, Slovis TL, Smith WL, Strife JL, Kanda MB, Myer E, Decter RM, Moreland MS. Imaging of the pediatric patient with seizures. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000 Jun;215(Suppl):787-800.

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

COMPLETE SUMMARY CONTENT

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SCOPE

DISEASE/CONDITION(S)

Seizures

GUIDELINE CATEGORY

Diagnosis

CLINICAL SPECIALTY

Family Practice
Neurology
Pediatrics
Radiology

INTENDED USERS

Health Plans
Hospitals
Managed Care Organizations
Physicians
Utilization Management

GUIDELINE OBJECTIVE(S)

To evaluate the appropriateness of initial radiologic examinations for pediatric patients with seizures

TARGET POPULATION

Children with seizures

INTERVENTIONS AND PRACTICES CONSIDERED

1. Magnetic resonance imaging (MRI), brain, without and with contrast
2. Computed tomography (CT), head, without and with contrast
3. Ultrasound (US), head
4. Fluorodeoxyglucose-positron emission tomography (FDG-PET), brain
5. Nuclear medicine (NM), single photon emission computed tomography (SPECT), brain

MAJOR OUTCOMES CONSIDERED

Utility of radiologic examinations in differential diagnosis

METHODOLOGY

METHODS USED TO COLLECT/SELECT EVIDENCE

Searches of Electronic Databases

DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The guideline developer performed literature searches of peer-reviewed medical journals and the major applicable articles were identified and collected.

NUMBER OF SOURCE DOCUMENTS

The total number of source documents identified as the result of the literature search is not known.

METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Weighting According to a Rating Scheme (Scheme Not Given)

RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Not stated

METHODS USED TO ANALYZE THE EVIDENCE

Systematic Review with Evidence Tables

DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

One or two topic leaders within a panel assume the responsibility of developing an evidence table for each clinical condition, based on analysis of the current literature. These tables serve as a basis for developing a narrative specific to each clinical condition.

METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus (Delphi)

DESCRIPTION OF METHODS USED TO FORMULATE THE RECOMMENDATIONS

Since data available from existing scientific studies are usually insufficient for meta-analysis, broad-based consensus techniques are needed for reaching agreement in the formulation of the appropriateness criteria. The American College of Radiology (ACR) Appropriateness Criteria panels use a modified Delphi technique to arrive at consensus. Serial surveys are conducted by distributing questionnaires to consolidate expert opinions within each panel. These questionnaires are distributed to the participants along with the evidence table and narrative as developed by the topic leader(s). Questionnaires are completed by participants in their own professional setting without influence of the other members. Voting is conducted using a scoring system from 1-9, indicating the least to the most appropriate imaging examination or therapeutic procedure. The survey results are collected, tabulated in anonymous fashion, and redistributed after each round. A maximum of three rounds is conducted and opinions are unified to the highest degree possible. Eighty percent agreement is considered a consensus. This modified Delphi technique enables individual, unbiased expression, is economical, easy to understand, and relatively simple to conduct.

If consensus cannot be reached by the Delphi technique, the panel is convened and group consensus techniques are utilized. The strengths and weaknesses of

each test or procedure are discussed and consensus reached whenever possible. If "No consensus" appears in the rating column, reasons for this decision are added to the comment sections.

RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

Not applicable

COST ANALYSIS

A formal cost analysis was not performed and published cost analyses were not reviewed.

METHOD OF GUIDELINE VALIDATION

Internal Peer Review

DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

RECOMMENDATIONS

MAJOR RECOMMENDATIONS

ACR Appropriateness Criteria®

Clinical Condition: Seizures -- Child

Variant 1: Neonatal seizures.

Radiologic Procedure	Appropriateness Rating	Comments
US, head	8	
MRI, brain, without contrast	5	
MRI, brain, without and with contrast	4	
CT, head, without contrast	4	
CT, head, without and with contrast	3	
FDG-PET, brain	1	

Radiologic Procedure	Appropriateness Rating	Comments
NM, SPECT, brain	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Partial seizures

Radiologic Procedure	Appropriateness Rating	Comments
MRI, brain, without contrast	9	
MRI, brain, without and with contrast	7	
CT, head, without contrast	7	
CT, head, without and with contrast	5	
FDG-PET, brain	5	
NM, SPECT, brain	5	
US, head	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Post traumatic seizures.

Radiologic Procedure	Appropriateness Rating	Comments
CT, head, without contrast	9	
MRI, brain, without	7	

Radiologic Procedure	Appropriateness Rating	Comments
contrast		
MRI, brain, without and with contrast	3	
CT, head, without and with contrast	2	
US, head	1	
FDG-PET, brain	1	
NM, SPECT, brain	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: First generalized seizure (neurologically normal).

Radiologic Procedure	Appropriateness Rating	Comments
MRI, brain, without contrast	5	
MRI, brain, without and with contrast	4	
CT, head, without contrast	4	
CT, head, without and with contrast	2	
US, head	1	
FDG-PET, brain	1	
NM, SPECT, brain	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Generalized seizure (neurologically abnormal).

Radiologic Procedure	Appropriateness Rating	Comments
MRI, brain, without contrast	8	
CT, head, without contrast	7	
MRI, brain, without and with contrast	6	To clarify an abnormality on the noncontrast MRI or if considering infection or inflammation.
CT, head, without contrast	2	
FDG-PET, brain	2	
NM, SPECT, brain	2	
US, head	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: Intractable or refractory seizures.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, brain, without contrast	9	
MRI, brain, without and with contrast	6	To clarify an abnormality on the noncontrast MRI or if considering infection or inflammation.
FDG-PET, brain	6	
NM, SPECT, brain	6	
CT, head, without contrast	5	
CT, head, without and with contrast	2	

Radiologic Procedure	Appropriateness Rating	Comments
US, head	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Febrile seizures.

Radiologic Procedure	Appropriateness Rating	Comments
MRI, brain, without contrast	2	
MRI, brain, without and with contrast	2	
CT, head, without contrast	2	
CT, head, without and with contrast	2	
US, head	1	
FDG-PET, brain	1	
NM, SPECT, brain	1	
Appropriateness Criteria Scale **1 2 3 4 5 6 7 8 9** **1 = Least appropriate 9 = Most appropriate**		

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

One of every 11 Americans who live to be 80 years of age will have at least one seizure. About 3% of the population has recurrent unprovoked seizures (epilepsy). In the United States, the estimated prevalence of epilepsy is 6.2 cases per 1,000 population. On the basis of 2000 census figures, this means that at least one in 1.5 million people in this country will have active epilepsy. A British population study found that 37% of patients with seizures are younger than 19 years of age. Thus, seizures present common management problems in medical practice in general and in pediatrics in particular.

Seizures are defined as discrete clinical events that reflect temporary physiologic brain dysfunction characterized by excessive and hypersynchronous discharge of cortical neurons. There have been a number of classification schemes of seizures. One frequently referenced is the International League Against Epilepsy (ILAE), as modified by Scheuer and Pedley. The clinical manifestations of a seizure in conjunction with an electroencephalogram (EEG) classify it as either generalized or partial. This is the most important dichotomy related to imaging. None of the current classifications, however, neatly fit into categories that can be used to propose imaging guidelines. The following categories create groups for which specific imaging algorithms seem appropriate. These categories group patients by age, precipitating event, and clinical manifestations of the seizure in conjunction with the EEG. Categorizing patients in this way helps to define specific imaging guidelines appropriate to each group.

Imaging Recommendations

The historical data are sometimes limited, and accurate determination of specific seizure category may be difficult. The imaging used in the initial investigation of a patient presenting with a seizure may require supplemental imaging as the seizure becomes more defined, more frequent, or refractory to treatment.

Neonatal Seizure

The incidence of neonatal seizures has been estimated to be between 80 and 120 per 100,000 neonates per year. Hypoxic ischemic encephalopathy is by far the most common cause of seizure in both term and preterm infants. Intracranial hemorrhage is the second leading cause. Together they account for nearly 75% of seizures in the neonatal period. Approximately 90% of infants with hypoxic encephalopathy experience the onset of their seizures within two days following birth. Seizures occurring beyond the seventh day of life are more likely to be related to infection or developmental defects. Ultrasound (US) has been the mainstay for imaging the neonate. The portability and ease of evaluation at the bedside make it an ideal method of evaluation. Computed tomography (CT) plays a role in defining the extent of hemorrhage and is useful in quantifying and characterizing extra axial collections. Magnetic resonance imaging (MRI), however, is becoming an increasing valuable tool, particularly in defining the extent of parenchymal injury. Diffusion imaging has added sensitivity to routine spin echo sequences. In addition, MRI has the greatest sensitivity for detecting intracranial developmental abnormalities associated with seizures, specifically malformations of cortical development. MRI-compatible incubators and the sophistication of neonatal care teams in managing critical neonates in the MRI environment have allowed for more sophisticated imaging.

Partial Seizure

The occurrence of a partial seizure implies a focal abnormality of the brain. Focality is also suggested through EEG analysis. Positive yields from imaging of patients with partial seizures, both simple (without loss of consciousness) and complex (with loss of consciousness), are considerably higher than those from imaging of patients with generalized seizures whose neurologic examination is normal. In one study, neuroimaging was positive in more than 50% of patients whose seizures had focal features. MRI was considerably more sensitive than CT.

Another study noted a 50% positivity rate for CT when neurologic findings were focal. A third study found seizures to be the presenting symptom in 12% of 81 consecutive children with primary brain tumors. Nine of ten in this series were focal seizures.

Seizures can result from developmental abnormalities, hemorrhage, neoplasm and gliosis, all of which can be detected by CT and MRI. MRI is considerably more sensitive than CT, particularly with subtle developmental abnormalities, small foci of hemorrhage, and metastases. The argument that CT is more accessible for emergent imaging of initial seizure is offset by the improved sensitivity of MRI. One study suggests limited justification for emergent CT as opposed to scheduled MRI in patients presenting with first time seizure. One exception might be the patient less than 2 years of age in whom the possibility of nonaccidental trauma should be considered as the precipitating event of a posttraumatic seizure. The rate of recurrence of partial seizures was considerably greater than that for generalized seizures. In one study, patients with partial seizures had a 94% rate of recurrence. Both positron emission tomography (PET) and single photon emission computed tomography (SPECT) (ictal and interictal) can be helpful in evaluating recurrent seizures when anatomic imaging is normal. In general, however, functional imaging (PET, SPECT, functional MRI, and even magnetoencephalography) are most appropriately reserved for refined evaluation when surgical intervention is contemplated.

Posttraumatic Seizure

CT and MRI both effectively define treatable pathology associated with intracranial trauma. In one study, CT identified 100% of the treatable lesions in patients with mild trauma as indicated by Glasgow coma scores of 13-15. In this study, although CT results were negative in 53% of patients, 7% of patients had lesions that required surgical intervention. MRI is more sensitive to parenchymal shear injuries. However, there is little indication that MRI provides any additional information beyond that obtainable by CT to redirect immediate treatment at the time of acute injury. An important subgroup to consider is the patient less than 2 years of age presenting to the emergency department with first time afebrile seizure. Posttraumatic seizure is not an uncommon presentation of nonaccidental trauma.

Generalized Seizure (less than 2 unprovoked seizures)

It is probably most appropriate to divide patients with generalized seizures into two subcategories: those who are neurologically normal, and those who present with positive neurologic findings. Neurologic abnormalities may be historical, such as developmental delay, cerebral palsy, or attention deficit disorder. Or they may be physical, as in postictal Todd's paralysis, or simply manifest as an abnormal sensorium. Fewer than 2% of patients will have an abnormal CT examination after a generalized seizure if they are neurologically normal with a negative EEG. In one study, none of the positive CT findings were treatable. In another study, 100% of abnormal studies had either a positive neurologic examination, a positive EEG, or a known malignancy. A third study reported only 6% positive CT examinations for generalized seizures, with nearly 50% positivity in focal epilepsy. Other researchers studied 500 consecutive patients presenting to an emergency department with first afebrile seizure. They defined 2 clinically significant high-risk

indicators of positive exam: 1) presence of predisposing condition, and 2) focal seizure. Only 2% of low-risk patients had positive imaging exams.

Generalized seizures with abnormal neurologic findings might best be imaged in a manner similar to partial seizures. A difficult task in the evaluation of seizures is discriminating a generalized seizure whose onset is precipitated by a focal epileptic event from one without a focal precipitant. Many of these patients however, demonstrate either a postictal neurologic finding or other neurologic abnormality including nonspecific findings such as developmental delay. Although one study reported that 83% of patients younger than 16 years of age at the time of initial seizure experienced a second seizure, 100% of seizures associated with a neurologic deficit recurred. The recurrence risk defined by another study included abnormal EEG and remote symptomatic seizures.

Intractable or Refractory Seizures

Refractory seizures, which are potentially treatable by surgical exclusion, define a small percentage of patients with seizures or epilepsy. In these patients, the use of multiple modalities is probably warranted. MRI is considered the most sensitive and specific anatomic imaging technique in the evaluation of these patients. It is more sensitive (84%) than SPECT (75%), which is somewhat more sensitive than CT (62%) in surgical patients with intractable seizures. Ictal SPECT has been useful in differentiating temporal lobe epilepsy from extratemporal lobe foci and provides noninvasive imaging information used in planning treatment strategies. The timing of the injection to optimize ictal SPECT has been analyzed. This practical limitation has made ictal imaging difficult. There is general agreement that the combination of ictal and interictal SPECT is the optimal method of SPECT imaging in the evaluation of seizure focus. PET is an alternative to SPECT for functional imaging and is most useful in patients with intractable partial epilepsy. Both have been used in some centers as a part of presurgical evaluation and planning.

Evidence that ^{18}F-fluorodeoxyglucose (FDG)-PET has prognostic value regarding the outcome of epilepsy surgery in refractory partial epilepsy is beginning to accumulate. PET in particular has been shown to be useful in evaluating residual foci of seizure activity in patients who have undergone unsuccessful surgical intervention. Tc-99m hexamethylpropyleneamine oxime (HMPAO) SPECT or Tc-99m ethyl cysteinate dimer (ECD) SPECT is currently more available than PET, although the emergence of PET CT has resulted in increased availability. Ictal and interictal SPECT have been shown to be of greater value than either alone but can be difficult to obtain. Pharmacologic provocation of a seizure focus has been studied as a way to more reliably obtain a true ictal exam.

Febrile Seizure

Aside from the exclusion of intracranial abscess or mass lesion associated with encephalitis, there is limited evidence to suggest that imaging adds additional relevant information in the evaluation of a febrile seizure. In a study of febrile seizures using Tc-99m HMPAO, there was some indication that a SPECT scan can identify areas of functional disturbance that are not apparent on CT; however, the supposition that delayed SPECT imaging two weeks after seizure might distinguish those patients with high risk of recurrence from those with low risk for recurrence

is not convincing. Febrile seizures appear to have late sequelae that can be identified in coronal MRI, but these findings are of little clinical significance at the time of the febrile event.

Seizure Syndromes

A number of seizure syndromes probably do not require imaging because they are sufficiently characteristic to be diagnosed clinically or through specific EEG patterns. Benign rolandic seizures, benign occipital epilepsy, and juvenile myoclonic seizures are fairly characteristic and rarely benefit from imaging. Patients with the malignant form of rolandic seizure without typical EEG findings may benefit from imaging. MRI is most likely positive when the EEG shows focal abnormality. West syndrome has been divided into symptomatic and asymptomatic forms. There is conflicting data as to the utility of SPECT and FDG-PET in the evaluation of West syndrome. MRI is probably indicated in symptomatic forms because there is a significant incidence of cortical dysplasia that can benefit from surgical management. The characteristic clinical presentation of absence seizures in childhood along with the classic EEG makes imaging unnecessary.

Summary

The appropriate imaging of pediatric patients being evaluated for seizures is variable and depends on the age at presentation, the seizure characteristics, the precipitating event, and the associated neurologic findings. US may be sufficient in the neonatal period, although CT or MRI may be helpful, particularly in refractory seizures. In other age groups, generalized and/or partial seizures can be imaged with either CT or MRI. MRI is considerably more sensitive than CT in defining structural abnormalities associated with a seizure focus. The positive imaging yield in partial seizures is significantly greater than that for generalized seizures. The yield in generalized seizures increases when accompanied by abnormal neurologic findings. Seizure syndromes such as benign rolandic seizures, absence seizures, and juvenile myoclonic seizures require little in the way of imaging. Febrile seizures may require imaging when a central focus of infection such as abscess is suspected clinically. CT is probably adequate to define treatable sources of post-traumatic seizures, although MRI is more sensitive to parenchymal lesions, which may represent a seizure focus. Refractory or intractable seizures might best be imaged with MRI followed by a functional study such as SPECT or PET if clinical correlation is lacking.

Abbreviations

- CT, computed tomography
- FDG-PET, fluorodeoxyglucose-positron emission tomography
- MRI, magnetic resonance imaging
- NM, nuclear medicine
- SPECT, single photon emission computed tomography
- US, ultrasound

CLINICAL ALGORITHM(S)

Algorithms were not developed from criteria guidelines.

EVIDENCE SUPPORTING THE RECOMMENDATIONS

TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The recommendations are based on analysis of the current literature and expert panel consensus.

BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

POTENTIAL BENEFITS

Selection of appropriate radiologic imaging procedures for evaluation of pediatric patients with seizures

POTENTIAL HARMS

Not stated

QUALIFYING STATEMENTS

QUALIFYING STATEMENTS

An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those exams generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

IMPLEMENTATION OF THE GUIDELINE

DESCRIPTION OF IMPLEMENTATION STRATEGY

An implementation strategy was not provided.

IMPLEMENTATION TOOLS

Personal Digital Assistant (PDA) Downloads

For information about availability, see the "Availability of Companion Documents" and "Patient Resources" fields below.

INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IOM CARE NEED

Getting Better
Living with Illness

IOM DOMAIN

Effectiveness

IDENTIFYING INFORMATION AND AVAILABILITY

BIBLIOGRAPHIC SOURCE(S)

Strain JD, Gunderman R, Blatt ER, Coley BD, Fordham L, Podberesky DJ, Prince JS, Expert Panel on Pediatric Imaging. Seizures - child. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 8 p. [26 references]

ADAPTATION

Not applicable: The guideline was not adapted from another source.

DATE RELEASED

1995 (revised 2006)

GUIDELINE DEVELOPER(S)

American College of Radiology - Medical Specialty Society

SOURCE(S) OF FUNDING

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

GUIDELINE COMMITTEE

Committee on Appropriateness Criteria, Expert Panel on Pediatric Imaging

COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE

Panel Members: John D. Strain, MD; Richard Gunderman, MD, PhD; Ellen R. Blatt, MD; Brian D. Coley, MD; Lynn Fordham, MD; Daniel J. Podberesky, MD; Jeffrey Scott Prince, MD

FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST

Not stated

GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: Strain JD, Kushner DC, Babcock DS, Cohen HL, Gelfand MJ, Hernandez RJ, McAlister WH, Parker BR, Royal SA, Slovis TL, Smith WL, Strife JL, Kanda MB, Myer E, Decter RM, Moreland MS. Imaging of the pediatric patient with seizures. American College of Radiology. ACR Appropriateness Criteria. Radiology 2000 Jun;215(Suppl):787-800.

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

GUIDELINE AVAILABILITY

Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

ACR Appropriateness Criteria® *Anytime*, *Anywhere*™ (PDA application). Available from the ACR Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

AVAILABILITY OF COMPANION DOCUMENTS

The following is available:

- ACR Appropriateness Criteria®. Background and development. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

PATIENT RESOURCES

None available

NGC STATUS

This NGC summary was completed by ECRI Institute on April 30, 2007.

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